sky at the time when the photographs were taken. Prof. Campbell suggests that cameras similar to those used by Perrine should be used in Labrador, Spain, Tunis, and Egypt. He also insists upon the necessity for setting up coronagraphs at each of these widely separated stations in order to determine whether or not any real changes take place in the corona during the eclipse.

The determination of the correct wave-length of the chief corona line is also suggested as being of great importance. Finally, he urges upon observers the vital importance of thoroughly testing all their instruments before leaving home, and of allowing themselves plenty of time to make the final adjustments whilst in the eclipse camp.

ACTUAL DISTANCES BETWEEN STARS.—By simple trigonometrical calculations, Mr. J. E. Gore has deduced some interesting facts regarding the probable actual distances between certain stars the parallaxes of which are known with some degree of certainty. Thus he has determined that Sirius and Procyon are separated by about half the distance between the former star and our own system, therefore Sirius as seen from Procyon would appear as a star of magnitude $-3 \cdot 08$. In the case of η and μ Cassiopeiæ, the actual distance between them is probably about one-fifteenth their distance from the sun, and their apparent brilliancies would therefore be about 225 times as great as they appear to us. In the case of double stars, these figures become much greater; for example, if we take 61 Cygni, the distance separating the components is about 55 astronomical units, and, as they are probably situated at some 515,662 astronomical units from the earth, their apparent brightness would be increased about 88 million times, or by 19·8 magnitudes, if seen at the distance which separates them. Similarly, the brightness of each of the components of α Centauri would be increased by 19·7 magnitudes (the *Observatory*, No. 345).

THE SUCCESSION OF CHANGES IN RADIO-ACTIVE BODIES.[1]

IT has been shown by Rutherford and Soddy that the radio-activity of the radio-elements is always accompanied by the production of a series of new substances possessing some distinctive physical and chemical properties. These new substances are not produced simultaneously, but arise in consequence of a succession of changes originating in the radio-elements. The radio-activity of these products is not permanent, but diminishes in most cases, according to an exponential law with the time. Each product has a distinctive rate of decay of activity, which has not, so far, been altered by any physical or chemical agency. The law of decay has been explained on the supposition that the product undergoes change according to the same law as a mono-molecular change in chemistry. The change occurs in consequence of the expulsion of an α or β particle, or both, and the activity of a product is thus a measure of its rate of change. While the products, like the emanations, and UrX, lose their activity according to an exponential law, the matter emanation X, which gives rise to the phenomena of excited activity, does not lose its activity according to a simple law. The experiments of Miss Brooks and the author, and of Curie and Danne, have shown that the decay of the excited activity of radium is very complicated, and depends upon the time of exposure to the exciting cause, viz. the emanation. The author has shown that the excited activity produced in a body by a short exposure in the presence of the thorium emanation increases at first for a few hours, passes through a maximum value, and then decays with the time according to an exponential law.

In the paper the curves of decay of excited activity of radium and thorium are given for both short and long exposures to the emanations, and it is shown that the law of change of activity with time can be completely explained on the theory that emanation X of thorium and radium is complex, and undergoes a series of successive changes.

The mathematical theory of successive changes is given in detail, and a comparison is made of the theoretical and experimental curves obtained for the variation with time of the excited activity. In the case of thorium, two changes are found to occur in emanation X. The first change is a "rayless" one, *i.e.* the transformation is not accompanied by the appearance of α, β, or γ rays. The second change gives rise to all three kinds of rays.

The decay of activity of emanation X of radium depends greatly on whether the α or β rays are used as a means of measurements. The curves obtained by the β rays are always identical with those obtained by the γ rays, showing that the β and γ rays always occur together and in the same proportion. The complicated decay curves obtained for the different types of rays, and for different times of exposure, can be completely explained on the supposition that there are three rapid successive changes in the matter deposited by the emanation, viz.:—

(1) A rapid change, giving rise only to α rays, in which half the matter is transformed in about three minutes.

(2) A "rayless" change, in which half the matter is transformed in twenty-one minutes.

(3) A change giving rise to α, β and γ rays together, in which half the matter is transformed in twenty-eight minutes.[1]

A similar rayless change is shown to occur in the "emanating substance" of Giesel.

The occurrence of a rayless change in the three radio-active bodies is of considerable interest. Since the change is not accompanied by rays, it can only be detected by its effect in the change or changes which follow. The matter of the rayless change is transformed according to the same law as the other changes. The rayless change may be supposed to consist either of a rearrangement of the components of the atom or a disintegration of the atom, in which the products of the disintegration are not set in sufficiently rapid motion to ionise the gas or to affect a photographic plate. The significance of the rayless changes is discussed, and the possibility is pointed out that similar rayless changes may occur in ordinary matter; for the changes taking place in the radio-active bodies would probably not have been detected if a part of the atom had not been expelled with great velocity.

The radiations from the different active products have been examined, and it is shown that the β and γ rays appear only in the last rapid change of each of the radio-elements. The other changes are accompanied by the emission of α particles alone.

Evidence is given that the last rapid change in uranium, radium, and thorium, which gives rise to β and γ rays, is far more violent and explosive in character than the preceding changes. There is some evidence for supposing that, in addition to the expelled α and β particles, more than one substance is produced as a result of the disintegration.

After the three rapid changes have taken place in emanation X of radium, there remains another product, which loses its activity extremely slowly. Madame Curie showed that a body, which had been exposed for some time in the presence of the radium emanation, always manifested a residual activity which did not appreciably diminish in the course of six months. A similar result has been obtained by Giesel. Some experiments are described, in which the matter of slow decay, deposited on the walls of a glass tube containing the emanation, was dissolved in acid. The active matter was found to emit both α and β rays, and the latter were present in unusually large proportion. The activity measured by the β rays diminished in the course of three months, while the activity measured by the α rays was unaltered. The active matter was complex, for a part which gave out only α rays was removed by placing a bismuth plate in the solution. The radio-active matter deposited on the bismuth is closely allied in chemical and radio-active properties to the active constituent contained in the radio-tellurium of Marckwald. The evidence, as a whole, is strongly in support of the view that the active substance present in radio-tellurium is a disintegration product of the radium atom. Since the radium emanation is

[1] Bakerian Lecture delivered at the Royal Society on May 19 by Prof. E. Rutherford, F.R.S.

[1] A statement of the nature of the three changes occurring in emanation X of radium was first given in a paper by Rutherford and Barne (*Phil. Mag.*, February). A brief account of the theory from which th results were deduced has been given in my book "Radio-activity" (Cambridge University Press). Later, Curie and Danne (*Comptes rendus*, March 14) arrived, in a similar way, at the same conclusions.

known to exist in the atmosphere, the active matter of slow dissipation produced from the emanation must be deposited on the surface of all bodies exposed to the open air. The radio-activity observed in ordinary materials is thus probably, in part, due to a thin surface film of radio-active matter deposited from the atmosphere.

A review is given of methods of calculation of the magnitude of the changes occurring in the radio-elements. It is shown that the amount of energy liberated in each radio-active change, which is accompanied by the emission of α particles, is about 100,000 times as great as the energy liberated by the union of hydrogen and oxygen to form an equal weight of water. This energy is, for the most part, carried off in the form of kinetic energy by the α particles.

A description is given of some experiments to see if the α rays carried a positive charge of electricity, with the view of determining experimentally the number of α particles projected from one gram of radium per second. Not the slightest evidence was obtained that the α rays carried a charge at all, although it should readily have been detected. Since there is no doubt that the α rays are deflected in magnetic and electric fields as if they carried a positive charge, it seems probable that the α particles must in some way gain a positive charge after their expulsion from the atom.

Since, on the disintegration theory, the average life of a given quantity of radium cannot be more than a few thousand years, it is necessary to suppose that radium is being continuously produced in the earth. The simplest hypothesis to make is that radium is a disintegration product of the slowly changing elements uranium, thorium, or actinium present in pitchblende. It was arranged that Mr. Soddy should examine whether radium is produced from uranium, but the results so far obtained have been negative.

I have taken solutions of thorium nitrate and the "emanating substance" of Giesel (probably identical with the actinium of Debierne) freed from radium by chemical treatment, and placed them in closed vessels. The amount of radium present is experimentally determined by drawing off the emanation at regular intervals into an electroscope. A sufficient interval of time has not yet elapsed to settle with certainty whether radium is being produced or not, but the indications so far obtained are of a promising character.

RECENT PUBLICATIONS IN AGRICULTURAL SCIENCE.[1]

THE United States Department of Agriculture has issued the fourth annual instalment of the great work upon which its Division of Soils has embarked, the detailed survey of the soils of the whole of the country. The area covered by the present report is little less than 18,000 square miles, which have been surveyed at a total cost of 12*s.* per square mile. The work is being carried on simultaneously in many parts of the States; the counties dealt with embrace some of the old settled eastern States like New York and New Jersey, the Carolinas and Virginia, the rich lands of Ohio, Kentucky and Illinois, also the recently settled districts in the Dakotas, Texas, Colorado and other areas of deficient rainfall, the Walla Walla wheat area on the Pacific slope, and the lately acquired dependency of Porto Rico.

The method adopted follows that of the earlier reports; a field party maps the distribution of the soils in each section and collects information as to the crops grown and their average yields, the conditions of labour and transportation, at the same time indicating the suitability of the land for new crops and systems of farming. Mechanical analyses of each type of soil are made at Washington and are set out in the report; occasionally chemical analyses are included; statistics of rainfall and mean temperature are also added.

The whole work is based upon the facts that different types of soil can be recognised and the areas which they occupy can be approximately mapped, and that particular crops and systems of farming can be associated with the various soil types, so that the agriculture of each area can be directed along the most appropriate lines and its farmers saved from many unprofitable experiments. While the volume contains no striking novelty, it is full of interest and instruction to the English student of agriculture or economics.

M. Tribordeau gives an account of the agricultural condition of the Pas-de-Calais, dividing it into regions based upon geological considerations of the nature of the subsoil. A description of each soil is given, generally accompanied by several analyses by M. Pagnoul; then follows an account of the agriculture, with reports in considerable detail of the system pursued on one or more farms of different sizes in the area. The varieties of each crop generally grown, the races of live stock, the yield, the conditions of labour, even the implements in use on each farm are carefully set out. The latter half of the volume deals more generally with the agricultural economics of the district, and discusses the position both financial and moral of the labouring class, the conditions of tenure, the societies and other means adopted for the encouragement of agriculture, particularly the spread of the movement for credit banks and cooperative associations. The work is liberally illustrated with maps, photographs and diagrams, and presents a valuable picture of the present critical condition of agriculture in western Europe.

The current volume of the *Journal* of the Royal Agricultural Society, which now appears annually only, is somewhat more exclusively occupied than usual with the work of the society. In addition to the usual prize lists there is a general account of the show held at Park Royal last June, another article on the machinery exhibited there, and a full discussion of the trials of wind pumping engines conducted by the society in 1903. Reports of committees and of the scientific officers of the society also bulk largely, including Dr. J. A. Voelcker's account of the experiments in progress on the farm at Woburn and at the Hills pot-culture station. Turning to the general articles, the interest that is being manifested in forestry is seen in the two opening papers; in one Mr. C. E. Curties treats generally of the management of British woodlands, and in the other Mr. R. Anderson deals with the utilisation of home grown timber and its bye products. Mr. Spencer Pickering describes his experiments at the Duke of Bedford's fruit farm at Woburn, which he has repeated on a different soil at Harpenden, on the ill effects produced by growing grass round apple trees.

The volume is completed by one or two statistical papers and an article by Mr. A. D. Hall on the manuring of grass land, in which he takes the Rothamsted experiments upon grass land as his starting point, and then proceeds to discuss the many other manurial experiments upon hay or pasture which are now in progress in various parts of the country.

[1] "Field Operations of the Division of Soils, 1902." By Milton Whitney. Pp. 842; with a case of maps. (Washington: U.S. Department of Agriculture, 1903.)

"Monographie Agricole du Pas-de-Calais." By M. Tribordeau. Pp. 296. (Paris: Société d'Encouragement pour l'Industrie Nationale, 1904.)

"The Journal of the Royal Agricultural Society of England," vol. lxiv. Pp. 420+clxxxviii. (London: John Murray, 1903.)

MAIDSTONE MEETING OF THE SOUTH-EASTERN UNION OF SCIENTIFIC SOCIETIES.

THE ninth annual congress of the South-eastern Union of Scientific Societies opened on the evening of June 9, when Sir Henry Howorth, the outgoing president, resigned his seat to Mr. Henry Rudler, who delivered the annual address at the Town Hall, Maidstone.

Mr. Rudler alluded to his address as a string of commonplaces, but in it some very important topics were touched upon. He considered, for instance, the constitution of scientific societies, and the matters to be discussed at their meetings in these days of great specialisation. He divided the members of such societies as constitute the union into those (few in number) who do the work and those (the majority) who like to see what is being done. Mr. Rudler was of opinion that the latter should have their wants realised as well as the specialists, for to put it on the lowest plane, the societies generally depended upon the financial support of those intellectual people who take a general interest in the progress of science without aiding in it themselves. Mr. Rudler's advice was to hold sectional meetings for the specialists, where the matters to be considered might be as technical as occasion required, and to